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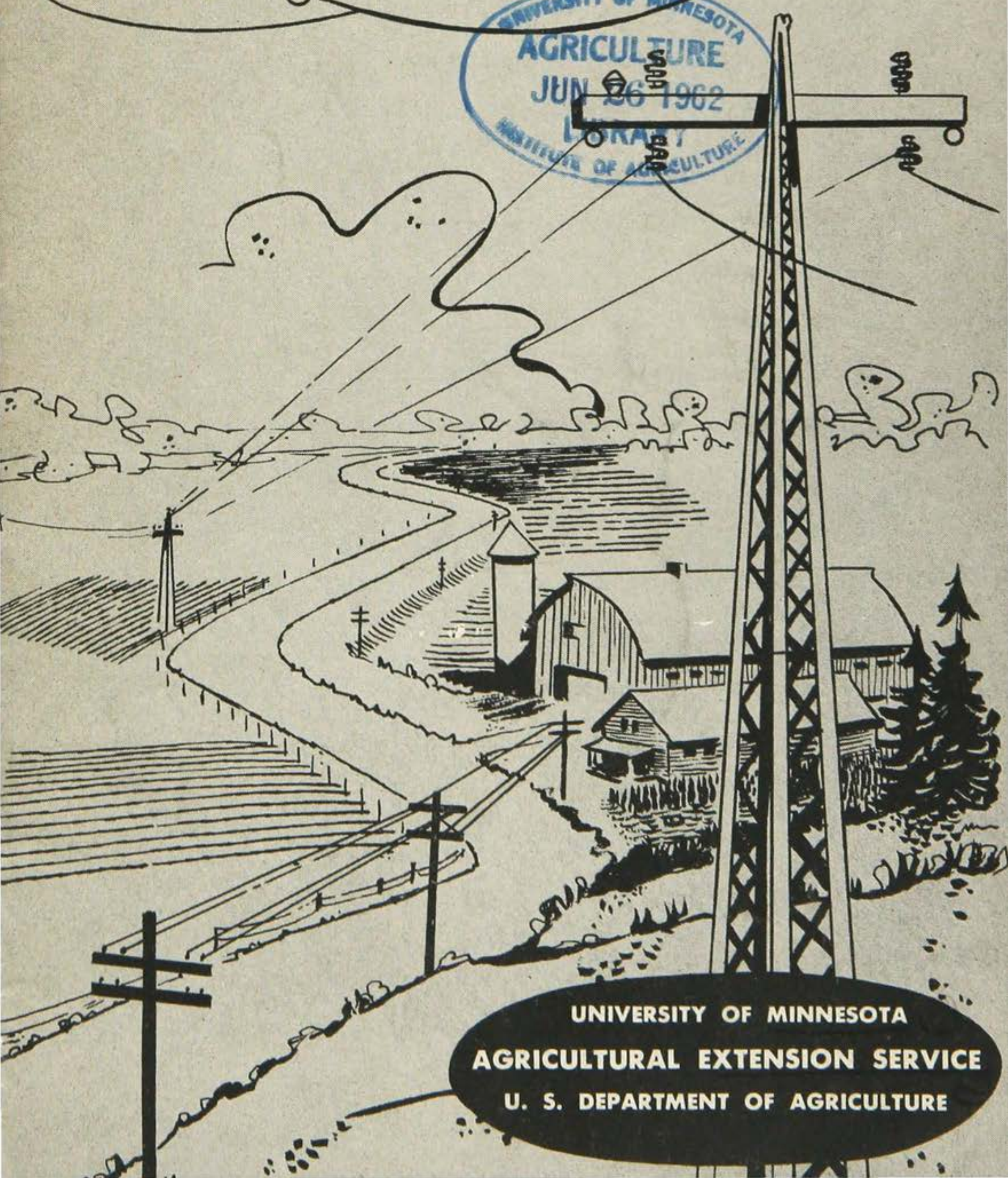
4H ELECTRIC PROJECT



UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION SERVICE
U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

4-H Electric Project

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ELECTRICITY is a form of energy which we can use to do work for us It has the advantage of being easily controlled and it can be easily changed to mechanical, heat, light, or chemical energy. It can be used to produce heat, cold, light, and power. This makes its field of application nearly limitless. Electricity comes to the farm in wires and is available at all times. We use only as much as is required by the work to be done, and we pay only for the energy used in doing this work. Thus in electricity we have a willing servant ready to perform many tasks for us on the farm.

Electricity is complex, yet to be able to discuss it intelligently one need only know certain terms and their meanings. Knowledge of these terms and of the methods used in distributing and utilizing electrical energy on the farm, is necessary before a boy or girl can use and understand electricity well.

Some of the more common terms and their meanings are:

Current: The flow of electrical energy along a conductor is known as an electrical current.

Ampere: The rate of flow of electric current along a conductor. It may be compared to the rate of flow of water through a pipe, which is gallons per minute. It is measured with an ammeter.

Volt: The unit of electrical force or pressure which makes an electric current flow through a wire. It is measured with a voltmeter.

Ohm: The unit of resistance to flow of current. It is comparable to friction in a water pipe. Resistance is useful in case of an electric heater but it is undesirable in most conductors. The resistance of any conductor depends on the material, its length, and its cross sectional area. A relationship between ohms, volts, and amperes known as Ohm's Law states that Volts = amperes times ohms or $V = IR$.

Cycle: Electrically it means that the current has changed from one direction to the other and back again to its original direction. A 60-cycle alternating current does this 60 times a second.

Watt: A unit for measuring electrical power. It is equal to volts multiplied by amperes, $P = VI$. Since the watt is a small unit, the kilowatt is commonly used. A kilowatt is equal to 1,000 watts. The instrument used to measure electrical power is the wattmeter.

Kilowatt-hour: A flow of 1,000 watts of electrical energy for a period of one hour. It is equal to the watts being used times the hours of operation, divided by 1,000. Electric power companies charge for electrical energy in terms of the number of kilowatt-hours used. (K.W.H.) A kilowatt-hour meter is used to measure this energy.

Work: The product of force times distance. The moving of an object is

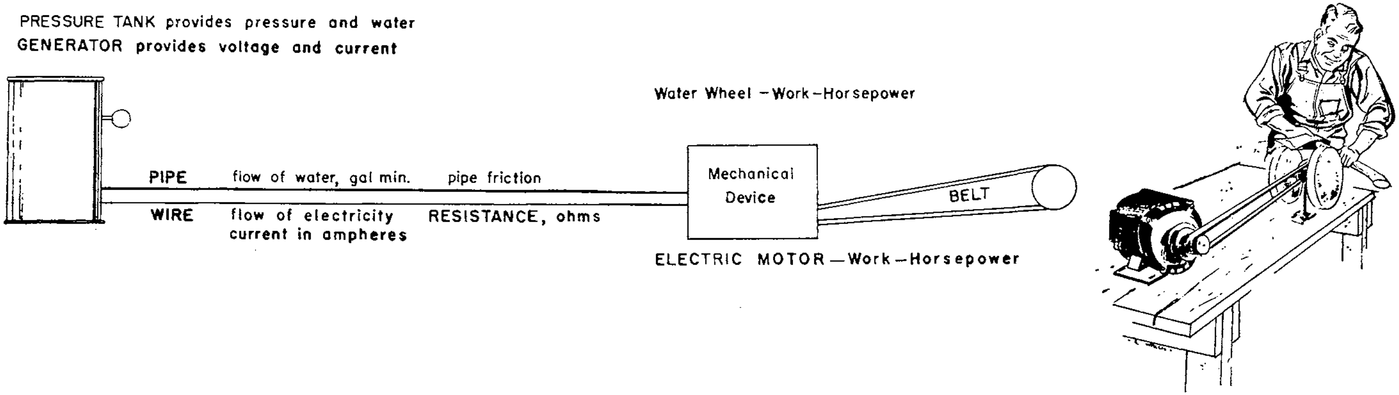


Fig. 1. A comparison of the use of electricity to a pressure water system for turning a grinder. It shows the relationship between the parts of the circuit and compares them to a water system which may be more familiar. Study the system carefully so you can understand the terms and what they describe.

work; pushing against it without moving it results in no work. Force times distance equals foot-pounds of work.

Efficiency: The ratio of the output of a machine to the input, usually expressed as per cent. It is always less than 100 per cent.

$$\frac{\text{Work output} \times 100}{\text{Work input}} = \text{percentage of effiency}$$

Horsepower: Work performed at the rate of 550 foot-pounds per second equals one horsepower.

746 watts = 1 horsepower

In practice, 1,000 watts are needed to produce one horsepower, due to friction and other losses.

Transformer: An electrical device used for changing the voltage of an alternating current circuit. It is used on the farm to step down the voltage from 7,200 volts to 120/240 volts for farm use.

Ground: An electrical connection to the earth.

Circuit: A continuous conducting path for the flow of electrical current. Voltage may be applied to a conductor without causing a current to flow.

Short circuit: A path for electric current through which it may flow with greater ease than through the regular circuit.

Fuse: A protective device which will open the circuit if an overload or short circuit appears.

Switch: A device that opens the circuit thus preventing the flow of current.

Direct current: Abbreviation is D.C. An electrical current that flows continuously in one direction. Not available to the farm.

Alternating current: Abbreviation is A.C. An electric current that flows first in one direction and then the other at regular intervals. All electricity supplied by a farm distribution system is alternating current.

Outlet: The point of entry into a circuit at which electrical energy is to be used. Lamps and other appliances are connected by means of a convenience outlet to the power supply.

The Relationship Between Current, Voltage, and Resistance

The transformer delivers 120 volts. This voltage is used to force the current through the resistance in the circuit which includes the lamp and the wires leading to it. The current is the same in all parts of the circuit, but the voltage becomes less and less as it goes along until it is zero when the current has come back to the transformer. The resistance of the wires is kept low so that nearly all the voltage is used at the light bulb. For example, if the

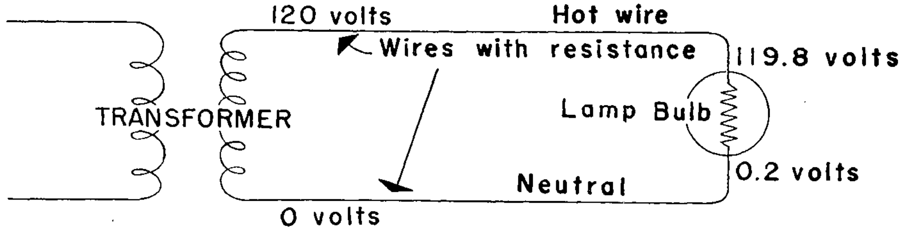


Fig. 2. The parts of an electrical circuit showing how voltage is used to make the current flow through a resistance. The resistance of the large bulb is useful because it gives us light.

lamp draws one ampere, there is one ampere in all of the circuit. The 120 volts are split up so that about 119.6 volts are used in the bulb, and the rest in the wires, but it is necessary to use the 120 volts in the circuit.

Distribution of Electricity on the Farmstead

The utility company supplies electricity to the farm through a distribution line. This line has a high voltage in order to reduce losses due to the resistance of the wire. At the farm, this high voltage is reduced to a safe voltage for use on the farm. This is done by a transformer located on a pole near the farm. The usual voltage for farm use is 120/240 volts. These voltages are used for safety reasons. High voltages require better insulation and equipment to prevent short circuits and other troubles. The current is alternating current, 60-cycle, single-phase. This is important to know when purchasing appliances.

Any appliance needing 240 volts is connected to the two colored wires. Those requiring 120 volts are connected to the neutral wire, which is white, and either of the colored wires.

The farmstead wiring service consists of these four main parts: (1) Main service, (2) Feeders, (3) Building services, and (4) Branch circuits with outlets.

Main service: The main service consists of the wiring from the transformer through the kilowatt-hour meter. It is made up of three wires which lead from the transformer to the meter location. This is usually a pole located at a central point of the farmstead. The main switch cabinet is below the meter. This switch makes it possible to cut off the flow of electricity to all of the farm buildings. Power suppliers usually have rules which govern the installation of this service. These rules must

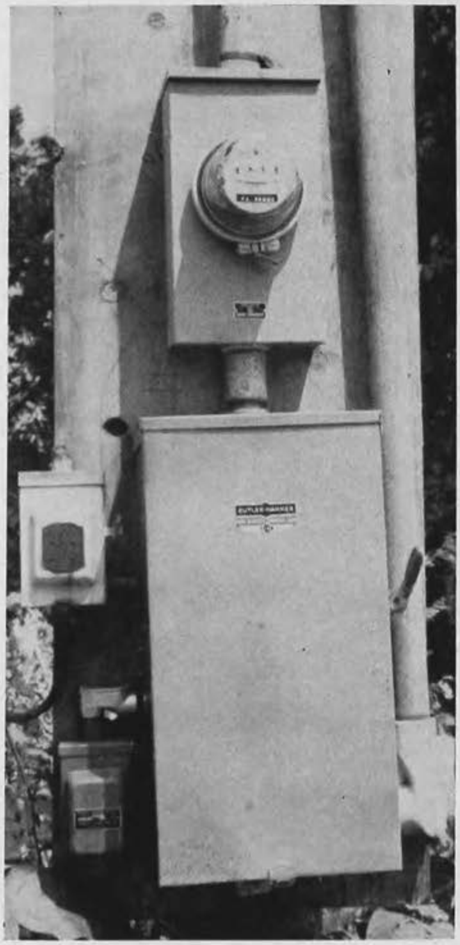


Fig. 3. A yard pole showing the kilowatt-hour meter and the main disconnect switch which controls all the electricity to the farm buildings. The two small switch boxes are for the pump motor and a power outlet in the yard.

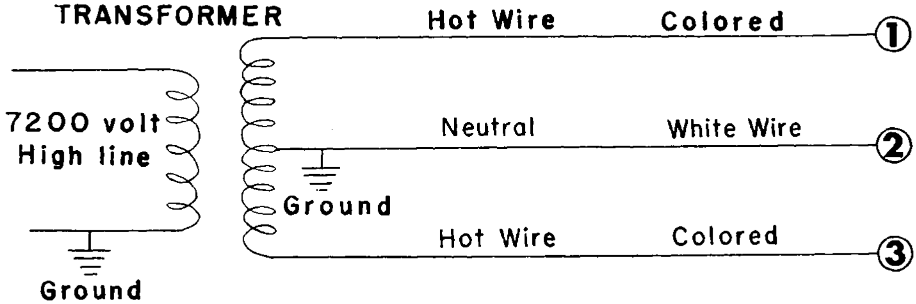


Fig. 4. This diagram shows the relationship between a transformer and a three-wire 120/240 volt service on the farm. One wire is grounded and is neutral. The other two wires each have a voltage of 120 volts in respect to the neutral wire, and total 240 volts between them.

be followed before electricity will be supplied to the farm.

Feeders: These wires must be large enough to carry the electricity to be used with the least amount of loss. Small wires restrict the flow of large quantities of electricity. If the load is large three wires should be run to each building. The use of three wires makes it possible to divide the load and thus save on wire costs.

A three-wire distribution system for use on a farmstead: The three wires make it possible to have 120/240 volts available for use in any building. Lighting and small appliances use the 120 volts. Large appliances such as motors, heaters, and other equipment which need a large amount of current use the 240 volts.

For example, the diagram (figure 5) shows how four 1200-watt—120-volt brooders would be connected to electricity. Each of the brooders needs 10 amperes to operate properly. Let us consider how this current flows as various combinations of the brooders are turned on.

a.) When all four (A, B, C, D) are operating, then wires (1) and (3) will carry 20 amperes each with none in wire (2). This is called a balanced load.

b.) When A and C are on, the condition is the same as (a.) except wires (1) and (3) carry 10 amperes each.

c.) With A and B on alone, wires (1) and (2) carry 20 amperes each with no current in wire (3).

d.) When A, B, and C are on, wire (1) carries 20 amperes, wire (2) carries 10 amperes, and wire (3) carries 10 amperes. This is an unbalanced load.

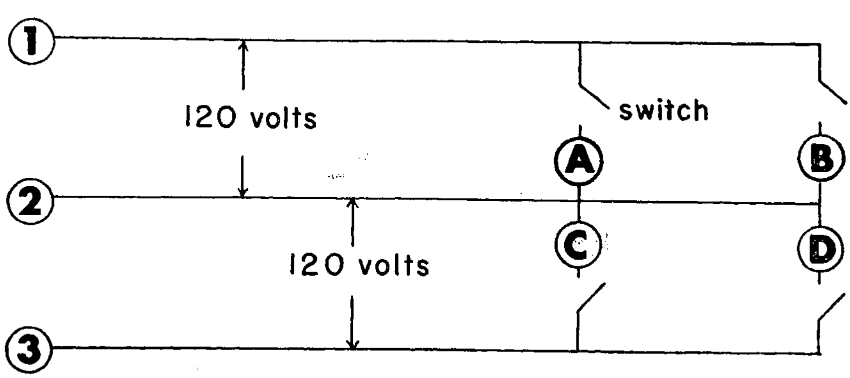


Fig. 5.

The use of wires also makes it possible to reduce the number of appliances on a circuit, improving the equipment's operation.

Building Service and Branch Circuits

This part of the wiring consists of an entrance box which has a cutout switch and fuses that can carry all the current needed in the building. From this box wires lead out to the lights, appliances, and other equipment used in the building. Each one of these is called a branch circuit and is individually fused in the entrance cabinet. The size of wire needed is determined by load while the maximum size fuse is determined by the wire size.

Usually there are two types of branch circuits. The smaller wire, usually No. 14 wire, is called a lighting circuit and is fused at 15 amperes. The other, usually a No. 12 wire, is called an appliance and is fused at 20 amperes. Individual circuits are used for motors ⅓ HP or larger, for all permanently located appliances larger than 1,000 watts, and for equipment where power interruptions must be kept at a minimum. These individual circuits are fused according to the load, either at the entrance box or in special switch boxes made for circuits such as these.

Fuses

A fuse is a device that protects electrical circuits against short circuits, overloads, and other damage due to defective equipment or practices. The wiring code requires that all circuits be protected by a fuse which acts as a safety valve. Whenever more current than the wire can safely carry passes through it, the fuse blows and opens the circuit and cuts off the flow of current.

A fuse contains a link which melts due to the high temperature caused by a heavy overload or a short circuit. This link is rated in amperes which is the maximum current it will pass before melting. Since each size wire can carry only so much current the size of fuse used must not exceed that limit. Thus we can limit the amount of current in any circuit by using properly selected fuses.

A circuit breaker serves the same purpose as a fuse. It automatically opens a circuit and can be reset to restore service once the trouble is corrected. There are no parts to be replaced each time the breaker opens. These breakers are rated the same way fuses are.

Ordinary fuses do not protect motors because they cannot take the extra amount of current needed to start the motor and still protect the motor after

Fig. 6. Various types of fuses are available for farm use. From left to right: plug fuse, cartridge fuse, delayed action fuse, nontamperable delayed action fuse with adapter, and a circuit breaker.

it is running. An ordinary fuse of the correct size to protect the motor against overload will blow each time the motor is started. There is now a special fuse known as a "delayed action" fuse which will stand a large overload for a short time without blowing. However, if the overload continues or a short circuit develops the fuse will blow. For motor protection the size of a delayed action fuse should be 20 per cent more than the name plate current. These fuses can be used in any circuit and can be purchased as nontamperable fuses thus preventing overfusing of a circuit.

If a fuse blows, inspect the circuit and determine the cause before replacing it with a new one. Under no circumstances put in a larger fuse as this destroys the circuit protection.

If fuses are continually blowing, the trouble may be either faulty equipment or an overloaded circuit. Faulty equipment *should* be repaired and, when necessary, new circuits should be added to divide the load between them.

Adequate Wiring

The wiring on a farm should be placed so that it meets the following requirements: (1) Adequate capacity, (2) Economy, (3) Can be easily expanded, and (4) Convenience and safety. The wiring plan should supply plenty of light where it is needed; it should have adequate switches and outlets of the right kind to connect the electrical equipment conveniently.

The wiring system must be safe and must stay safe. It pays to use the right materials and have them installed by a qualified electrician. He will select and install materials that conform to the state and local codes. Those electrical codes prescribe minimum standards for materials and installation practices. If the wiring is planned for future requirements it will be electrically safe and adequate. Many farms in Minnesota have wiring that is becoming inadequate.

The first noticeable effect of inadequate wiring is a dimming of the lights whenever a motor starts. Heating equipment such as irons, brooder lamps, and stoves slow up and take longer to do their job. This is not too serious but electric motors burn out as a result of inadequate wiring.

The reason for these difficulties is that the wires are not large enough to carry the required current. Whenever there is a flow of electricity, voltage is needed to force the current through the wires, and if the wires are too small, there is a loss of electricity. The resistance in the small wires causes the wires to heat and lower the voltage available for the appliance. This heating effect is lost energy in kilowatt-hours for which you must pay but cannot use. What is more, this overheating will eventually damage or destroy the insulation that covers the wire, which increases energy losses and may start a fire.

To realize full value of electrical equipment, wires must be able to carry the current at the lowest practical voltage drop. Some helpful hints to achieve this are:

1. Three wires can carry twice as much electricity as two; this makes it possible to divide the 120-volt load and also makes it possible to operate equipment on 240 volts. Study the diagram on page 7 which shows how to connect four brooders on a three-wire supply.

2. Motors of ⅓ HP or larger in size should be operated on 240 volts. Equipment which operates on either 120 or 240 volts requires ½ as much current when operating on 240 volts. Higher voltage will result in lower current flow and will require smaller wires for the same amount of power. Wire of sufficient size should be used so that it will carry the present and planned loads.

Actual size of wire	Number	Allowable current Amperes	Resistance Ohms per 1000 ft.
	16	8	4.02
	14	15	2.57
	12	20	1.62
	10	30	1.02
	8	40	.62
	6	55	.40
	4	70	.25
	2	95	.16
	0	125	.10
	00	150	.08

Fig. 7. The comparative sizes, current carrying capacity, and resistance of wires commonly used on Minnesota farms.

Electrical Safety

As mentioned in the section on adequate wiring, a properly wired system is safe. To keep this system safe, care must be taken to prevent any breakdown in the conductors or appliances used in the circuit. A faulty wiring system usually is caused by a breakdown in the insulation of the wire which keeps the electricity confined to its rightful path. A breakdown in the insulation is caused by: (1) Overloading the wires, (2) Moisture and other fumes, or (3) Physical damage or lightning.

Moisture is especially bad as it is also a good conductor of electricity. This makes any place such as a bath room, basement, barn, or well pit a potential hazard. Moisture on the skin lowers the resistance of the body and makes it a better conductor of electricity.

Electricity becomes dangerous to humans and animals whenever they provide a better path to the ground than the electrical circuit. Voltage gives one a shock, current kills. A current of 75/1000 amperes will injure animals. Whenever a short occurs a piece of equipment becomes "hot" and when one touches it he receives a shock. This is a warning; turn off the equipment and check carefully for a break in the insulation. Not only is this condition dangerous but it represents a current leak that costs money on the meter.

To keep the electrical system on your farm safe:

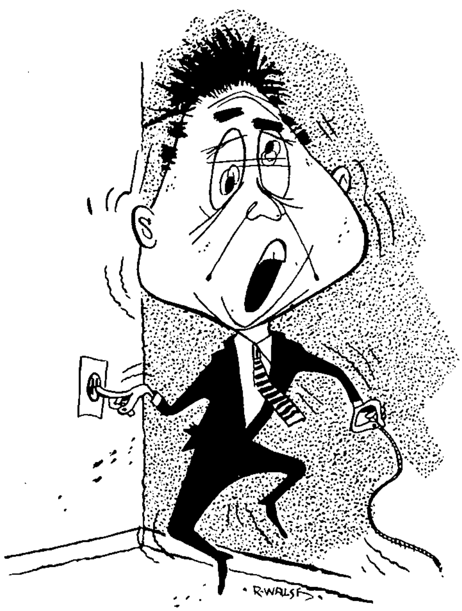


Fig. 8. Never allow your body to complete an electrical circuit.

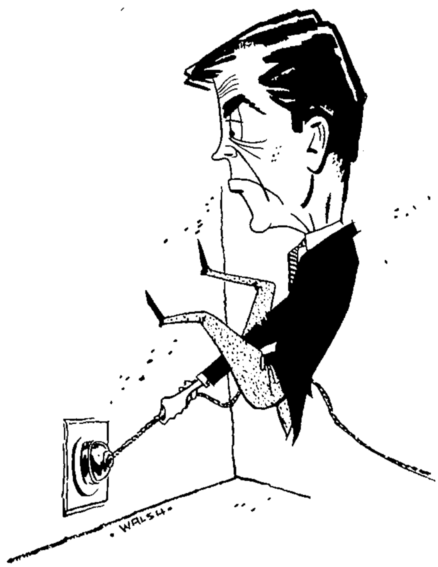


Fig. 9. Never pull on an electrical cord; always grasp the plug, then pull it out.

1. Know how everything works and fits into the electrical picture on the farm.

2. Inspect the wiring regularly, looking for breakdowns in the insulation and for places that will create hazards in the future. You may need assistance from your electrician to do some of this.

3. Ground all equipment whenever possible. A No. 8 wire to a good ground is the best idea. The ground rod should be long enough to reach moist ground at all times.

4. Never overload circuits by overfusing the wires.

5. Always turn off the electricity when working on any equipment or appliances.

6. Use equipment and appliances that are approved by the Fire Underwriters' Laboratory; they are vitally interested in your electrical safety.

7. Inspect the wiring in damp places periodically. Be careful to check places where the wires pass through walls or beams to see if the insulation is broken down or damaged.

If the victim of electric shock has ceased breathing, it is necessary to ap-

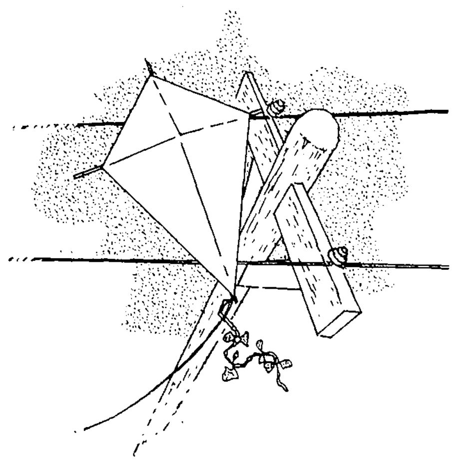


Fig. 10. Be careful with kites or machinery around overhead wires. You may accidently touch the wires and electrocute yourself.

ply artificial respiration immediately to save his life. The victim must be freed from the live conductor but the rescuer must not come in contact with the live circuit himself in order to avoid being a victim. Care must be taken not to touch the victim until he is freed. Use a nonconductor like dry wood to move the wire from the victim. It is well for the reader to know the latest method of applying artificial respiration.

Electric Motors

Electric motors can do many back breaking jobs on the farm. They are safe, cheap, and easy to maintain. Perhaps the outstanding advantage of the electric motor is its long life and its dependability. There are only two bearings and two or three other moving parts and these are subjected to only light wear. If the motor is properly protected it should last 25 years. The electric motor is easy to start and inexpensive to run. Its direction of rotation can be changed and it has a high overloading capacity for short periods of time. A ¼ horsepower motor can do more work than a man can. Thus if the job can be mechanized, the electric motor will save time, money, and many a sore back.

Four types of single-phase motors are found in general use on the farm. They are: split-phase, capacitor, repulsion start—induction run, and universal.

The main difference in the first three types is in the method used to start the motor turning. Electric motors found on farms need an initial push to start them turning and the names of the types indicate how this is done.

The universal motor can be used on either direct or alternating current. It will start a fairly heavy load and is usually used on small appliances, coming as part of the appliance.

The three important points for the care of a motor are to keep the motor "CLEAN, DRY, and LUBRICATED." If

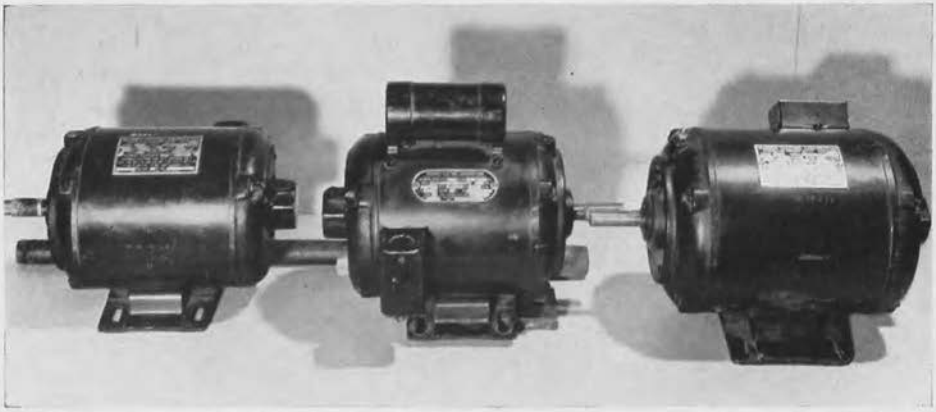


Fig. 11.	**Split phase**	**Capacitor**	**Repulsion-induction**
Cost	Low	Medium	High
Construction	No brushes	No brushes, has condenser	Brushes
Size most used	1/20 to ½	1/6 to 7½	1/6 to 10
Starting ability	Low to medium	Medium and high	High
Starting current	High	Medium to low	Low

dust and dirt are allowed to accumulate in a motor, it will overheat, and heat is the worst enemy a motor has. Keeping a motor dry will prevent short circuits. A motor needs to be lubricated at regular intervals with a small amount of oil. It is well to follow the manufacturer's instructions for the type of oil to use.

New motors should be selected according to the job they will be required to perform. If an appliance is to be used often or if automatic operation is desirable, it is better to have a motor permanently attached.

A name plate is attached to each motor which tells its horsepower output, speed in revolutions per minute, and voltage and ampereage required for operation.

Reading the Meter

Electricity is measured by the electric meter in kilowatt-hours (K.W.H.). A K.W.H. is 1000 watts used for one hour, 500 watts used for two hours, 100 watts used for 10 hours, etc. Two types of meters are used, the speedometer dial and the pointer dial. The speedometer dial is read the same as a car speedometer.

A pointer dial meter takes a little longer to read. The reading will be the four numbers indicated by the pointers. Start at the dial on the right and read to the left. When a pointer is between two numbers, always read the lower number.

The amount of electricity used in one month can be determined by subtracting the reading at the beginning of the month from the reading at the end of the month. If the reading on June 1 was 4297 and the reading on July 1

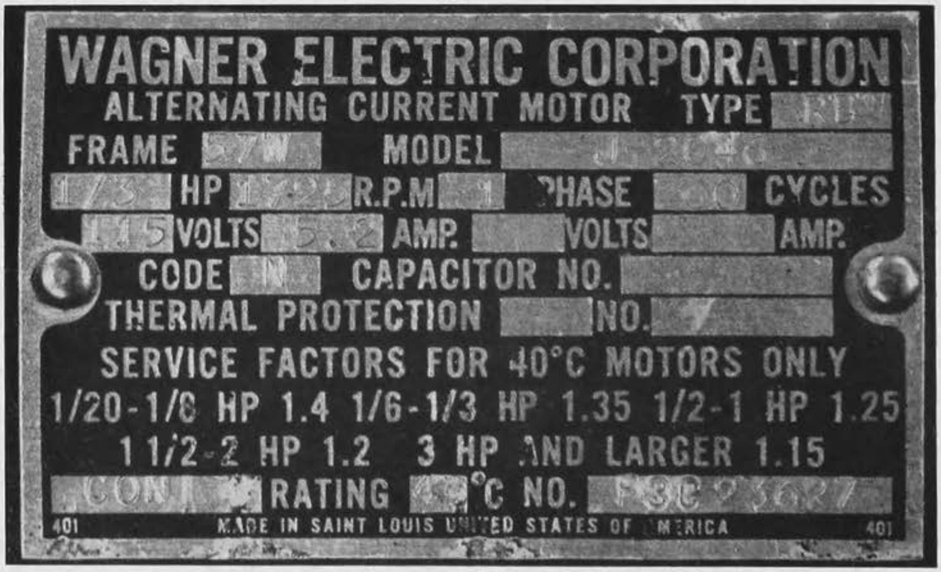
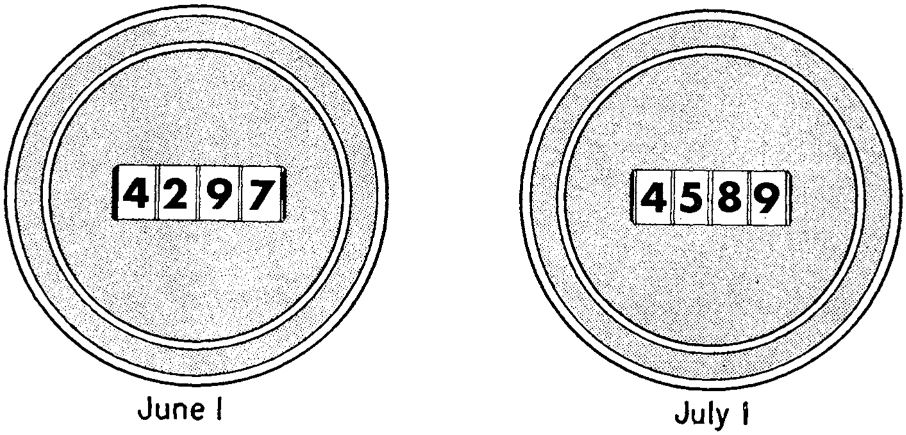


Fig. 12. The name plate of an electric motor. All of the information about rating and electrical needs of the motor is on this plate.

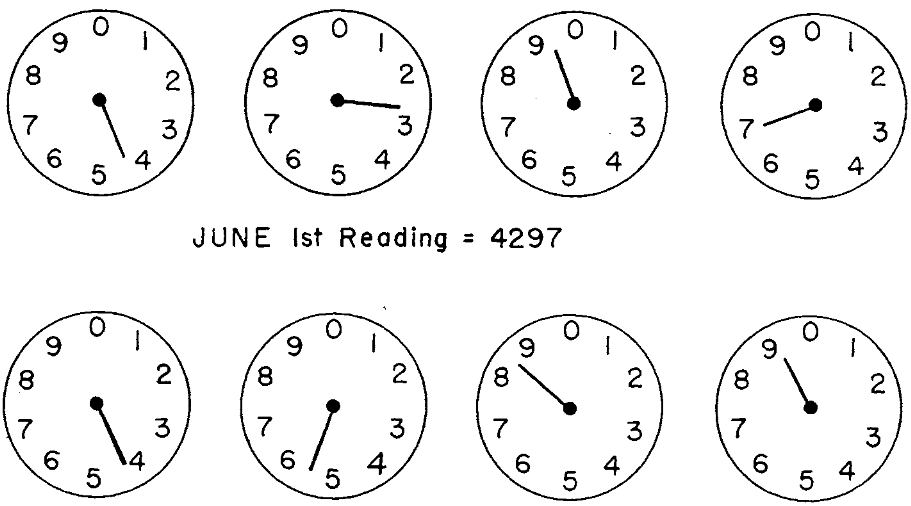


• Speedometer Dial Kilowatt Hour Meter

Fig. 13.

was 4589. 292 K.W.H.'s were used during the month of June (4589—4297=292).

Electric rates vary in different localities. A copy of the rates can always be obtained from the power supplier. Rates are set up so that the more electricity used the cheaper it becomes per K.W.H. A minimum charge per month is often made regardless of how little



JULY 1st Reading = 4589

POINTER DIAL KILOWATT HOUR METER

Fig. 14.

current is used. A typical rate schedule follows:

40 or less K.W.H. \$4.00 per month; this is the minimum charge
next 40 K.W.H. @ 6¢ per K.W.H.
next 120 K.W.H. @ 3¢ per K.W.H.
additional K.W.H. @ 2½¢ per K.W.H.

The total bill for 292 K.W.H. used is figured as follows:

40 K.W.H. 4.00 (minimum charge)
40 K.W.H. @ 6¢ = 2.40
120 K.W.H. @ 3¢ = 3.60
92 K.W.H. @ 2.5¢ = 2.30

Total 292 K.W.H. \$12.30 plus taxes, if any.

Many power suppliers offer a special low rate for water heaters and other equipment which can be operated at the "off peak" periods of the day. Such equipment has a special meter controlled by a time clock set by the power supplier, thus making current available to the equipment during the night and at certain times during the day when the demand on the power line is low.

Inventory of Electrical Equipment

The amount of electrical energy which appliances consume is measured in units. A name plate is attached to many showing the volts required and the watts consumed when the appliance is plugged into an electric outlet. Other appliances may have the same information stamped on them, usually near the bottom. Light bulbs usually have this information stamped on the large end of the bulb. The information may be given in terms of volts and amperes, in which case the watts can be determined by multiplying the volts times the amperes. 115 volts times 4.4 amperes = 506 watts.

Voltage is frequently given as shown in figure 15. This means that the equipment will operate satisfactorily at any voltage between 110 and 120.

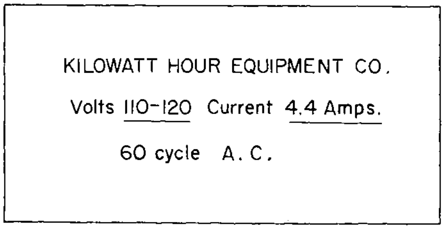


Fig. 15.

In order to become more familiar with the power requirements of electrical equipment, check all electric appliances in the household and tabulate the data in a table as shown below.

Appliance	Volts	Watts	Amperes	H.P.	Cost per hour
Toaster	115	1,200			
Refrigerator motor	115		2½	⅓	
Light bulb	110-120	100			

Equipment for the Project

A good set of tools is necessary to do satisfactory work in the electrical project. If you buy the tools yourself, it is wise to buy good ones. Such tools will last a long time if treated right.

The following list of tools is a minimum with which to begin your project. More should be added as occasion demands.

1. Hammer
2. Screwdriver
3. Needle nose pliers

Fig. 16. The tools needed for a beginner's project in 4-H electricity.

4. Jack knife
5. Soldering iron
6. Resin-core wire solder
7. Test lamp
8. Plastic tape

Care of Tools

Keep at least one blade of the jack knife sharp enough to cut insulation. A scout knife is good because it has other useful parts besides the cutting blades. Always cut away from you with a knife.

If you want your pliers to last and give satisfactory service, *don't* use them as a hammer.

Keep grease and oil off the end of the screwdriver when you use it. Hold your work in a vise or on a solid surface when tightening or loosening a screw. This will reduce the danger of the blade slipping and causing possible injury. Don't use the screwdriver as a chisel, punch, or pry. Use a screwdriver that fits the slot in the screw. Work away rather than toward yourself to avoid accidents in case the screwdriver slips. When through with the screwdriver put it down rather than in your pocket. The sharp point sticking out could cause considerable damage to yourself, others, or furniture, should you forget and sit down.

Splices and Connectors

In electrical work, it is often necessary to join two or more wires together. The joints are called splices and unless made correctly, they may become a source of trouble and even danger. A poor splice may cause loss of voltage, faulty operation of electrical equipment, and radio or TV interference, to say nothing of fire. In order to make a good splice it is necessary to:

1. Remove the insulation down to the bright metal.

2. Make the splice as strong as the original wire.

3. Solder the connections to have good electrical contact.

4. Replace the insulation with an amount equal to the original insulation.

Remove insulation

Insulation can be removed by crushing it with an electrician's pliers or by cutting it with a knife.

If electrician's pliers are used, place the wire between the handles of the pliers up close to the jaws. Crush the insulation and then strip it from the wire with the plier jaw. It is usually necessary to scrape the wire clean with a knife.

When using a knife to remove the insulation, hold the blade at the same angle you would when sharpening a pencil, then cut off the insulation. Care must be exercised not to cut the wire.

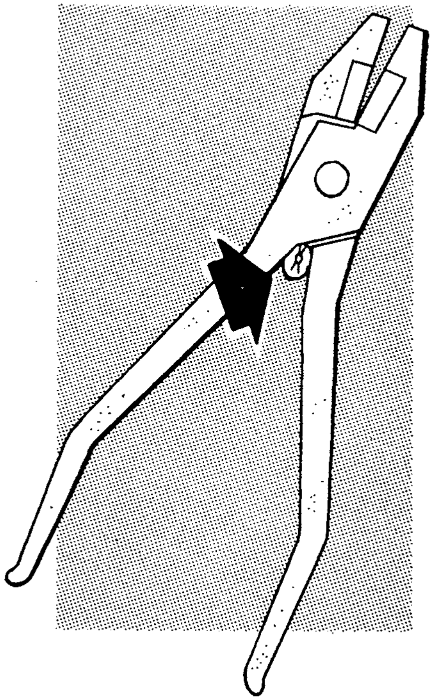


Fig. 18. Crush the insulation on an electric wire between the handles of an electrician's pliers.

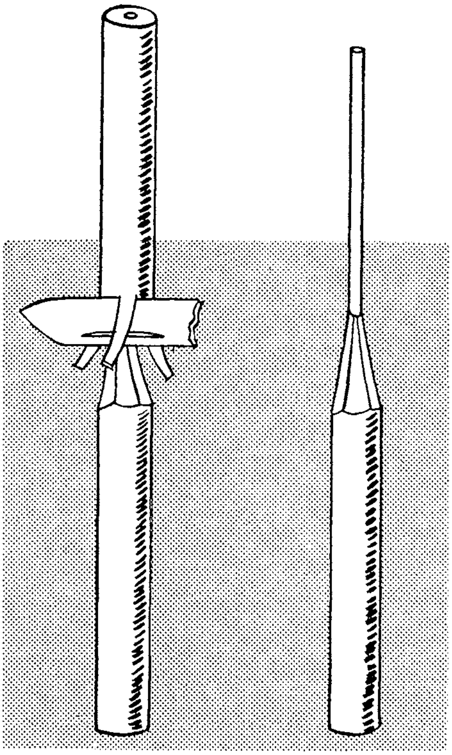


Fig. 17. To remove insulation from a wire, cut at the same angle as when sharpening a pencil. Be careful not to nick the wire, for it may break at that point if it's bent.

Splicing

The common or Western Union splice is used to splice two wires to form one continuous wire. If correctly made, the two wires joined will be as strong as the original.

To make this splice:

1. Remove about 3 inches of insulation from the end of each wire.

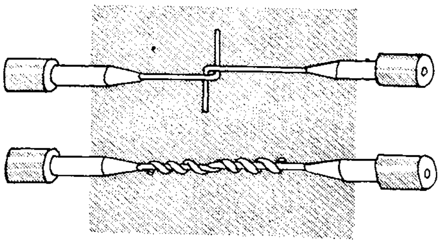


Fig. 19.

2. Clean the wires by scraping with a knife.

3. Make a right angle bend in each wire near the insulation.

4. Hold the wires together and twist them in opposite directions.

When it is desired to splice an additional wire onto a continuous wire the center top splice is used.

1. Remove about 1½ inches of insulation from the main wire and 1½ inches of insulation from the end of the wire to be attached.

2. Clean both wires by scraping with a knife.

3. Wrap the wires as shown in figure 20.

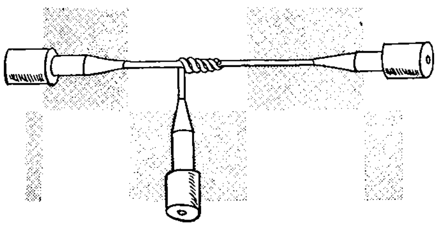


Fig. 20.

Soldering

The splice puts the two wires together but may not give good electrical contact. To make a good electrical connection, the joint should be covered with solder. Soldering may be done with an alcohol or gasoline blow torch, an electrically heated or an externally heated soldering iron. Regardless of the method used the wires must be clean and bright before soldering is attempted.

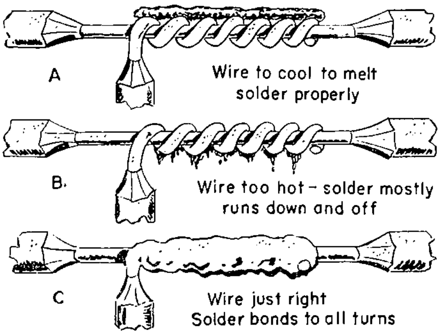


Fig. 21.

In addition to the solder, a flux must be used to help the solder attach itself to the copper wire. For electrical work this flux should be a rosin rather than an acid. Most manufacturers make solder with a flux in it. When this type of solder is used, additional flux is not necessary.

For the actual job of soldering a joint, heat the wires by applying the hot soldering iron directly to the joint bringing the wire up to the correct temperature. When the wire is hot put the solder directly on the joint.

It requires some experience to know how to keep the soldering iron at the right temperature. A simple test is to put the point of the iron against a piece of soft wood. If the wood at the point of contact begins to smoke and slowly turns brown the iron is at approximately the correct temperature. If there is a rapid charring of the wood, the iron is too hot.

When the wire is not hot enough and the solder is applied, the solder may not stick to the wire. On the other hand, if the wire is too hot, most of the solder will melt and run off.

Taping of Splice

After the joint has been soldered, it is necessary to replace the insulation that was removed. This is commonly done with tape. The joint itself is covered with a rubber tape which is made

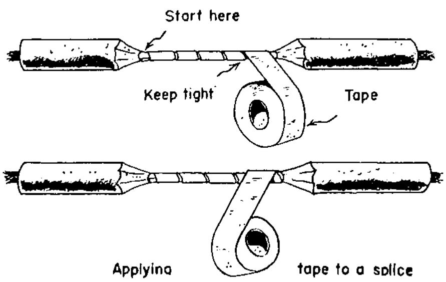


Fig. 22.

of a high-grade of rubber which vulcanizes the layers which overlap each other. In applying the tape, begin at one end and wind it diagonally toward the opposite end, letting each successive turn overlap a small amount. Be sure and cover all of the exposed parts of the wire to a thickness equal to the original insulation. This rubber tape is then covered in the same manner with friction tape which gives it mechanical protection.

In recent years a new plastic tape has replaced the rubber and friction tapes. The material is tough mechanically and has a high insulating value, so it only is necessary to put on a relatively thin layer of this tape to replace the older types. It is applied in the same manner as rubber tape.

Projects for Beginners in Electricity

Making an Extension Cord

A heavy duty extension cord is a handy thing to have about the farmstead. It can be used to provide electric power in out of the way places, on special jobs, or in case of emergency. An extension cord should never be used in place of permanent wiring.

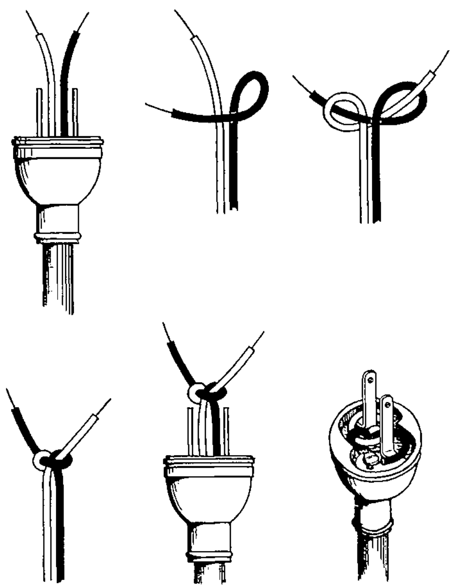
If number 16 wire is used the cord will be adequate to serve many pieces of electrical equipment, including a ⅓ horsepower motor.

Materials needed:

1. Eight or more feet of 2-wire number 16 heavy duty, rubber covered cord.
2. A heavy duty grip type plug, heavy duty connector cap, and cord connector base.
3. Jack knife, screwdriver, and electrician's pliers.

Procedure:

1. Push wire through plug, remove about 3 inches of the rubber covering and separate the two wires. There may be an outer insulation fabric over the two individually insulated wires. If so, exercise care in removing the fabric to avoid damaging the insulation on the wires.
2. Tie the underwriter's knot. This knot fits inside the plug and takes the strain off the wire ends attached to the screws should the plug be improperly removed by a jerk on the wire. Plugs should always be removed by a pull on the plug itself rather than on the cord.
3. Remove insulation from individual wires so that contact can be made with



UNDERWRITERS KNOT

Fig. 23.

the binding screws. Cut wires to proper length.

4. When using stranded wire, twist the strands together and coat with solder to prevent loose strands or whiskers which might cause a short circuit.

5. Wrap the wires clockwise around the contact prongs and clockwise around the binding screws. Tighten screws firmly.

6. The cap is attached in the same way, except that the wires cannot be placed on the outside of the contact prongs.

Repairing Heavy-Duty Appliance Cords

Appliances which produce heat such as electric irons, toasters, pop corn poppers, and bath room heaters have heavy cords covered with asbestos. These cords, particularly on electric irons, frequently become worn or damaged near the plug. Plugs may become worn or damaged through careless handling. In replacing the plug follow these steps. NEVER REPLACE THE ORIGINAL CORD WITH AN ORDINARY LAMP CORD.

1. Take plug apart by loosening, lift out terminals and spring guard.

2. Cut off damaged part of the cord. Remove about 2 inches of the heavy asbestos covering and separate the wires. Thread wrapped around the end of the cover will keep it from raveling.

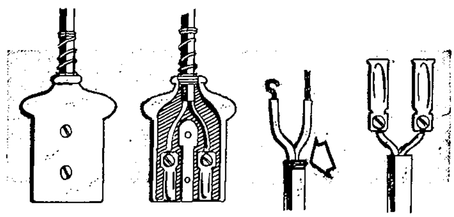


Fig. 24. The method used to connect a cord to a heavy-duty appliance plug.

3. Remove about ½ inch of rubber insulation from the end of each wire with a knife. Twist the ends of the wire together and coat with solder.

4. If the plug is damaged replace it with a new one.

5. Put cord through spring guard and attach to terminals of plug. Make sure that the plug end of the spring guard is toward the plug.

Making a Test Lamp

A test lamp is very useful in testing circuits and locating blown fuses and short circuits. It can be easily made at very little cost. To make a test lamp, a weatherproof socket with rubber covered wires attached (sometimes called a pigtail socket), a 25-watt, 120-volt light bulb, and a roll of friction tape are required.

Follow these steps:

1. Remove about 1 inch of insulation from the end of each lead wire. Twist the strands of each bare wire until they are tight, and coat with solder.

2. Screw the light bulb into the socket tightly so that none of the brass at the base of the bulb is showing. If this cannot be done, wrap any exposed

TEST. LAMP

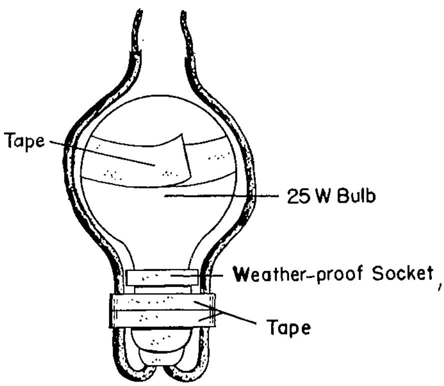


Fig. 25.

metal with tape to avoid the danger of getting a shock from it. Exercise due care in using the test lamp. KEEP YOUR HANDS AND FINGERS ON THE INSULATED SECTION OF THE SOCKET AND WIRE. DO NOT TOUCH THE EXPOSED ENDS OF THE WIRE WHEN THE LAMP IS IN USE.

Assembling a Brass Shell Socket

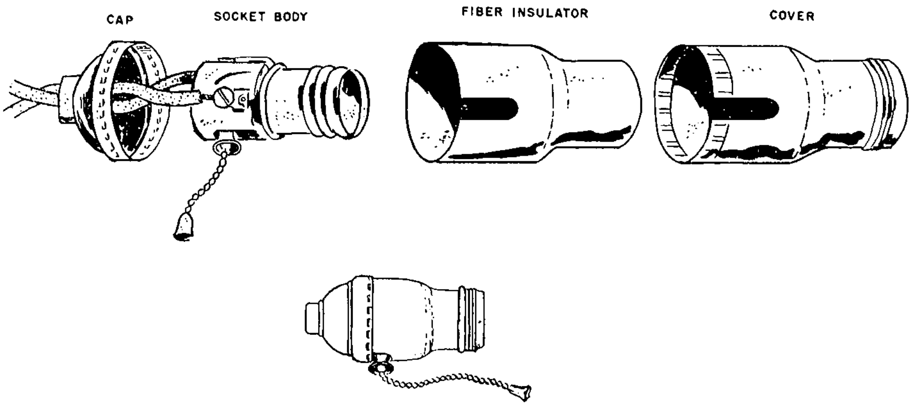
The brass shell socket with a key switch or pull chain is used on some electrical fixtures. The metal shell of the socket is made of two sections held together by interlocking perforations at the band just above the pull chain or key. To separate the sections, grasp the socket and squeeze the shell, near the word "press," with the thumb. Give the cover a slight twist in either direction and lift it off. The fiber insulator and the socket body can then be removed. Note how the parts fit together so they can be reassembled properly.

A new socket can be attached in the following manner:

1. Place the cord through the cap. The cord is usually fastened to the fixture so, if this is not done, the cap cannot be fastened.
2. If sufficient wire is available, tie an underwriter's knot. Do so, leaving about 1½ inches of wire to run to the binding screws.
3. Strip about ¾ inch of insulation from each of the wires and twist the loose strands. It is desirable to put a drop of solder on the end of each wire.
4. Place the wires under the binding screws and bend eye loops in the proper direction. Tighten binding screws.
5. Replace fiber insulation shell over the socket body, attach socket body to cap, and the job is complete.

Speed Reducer

Electric motors commonly run at a speed of 1,740 r.p.m. (revolutions per minute). The speed of any motor is given on the name plate. Since it is usually necessary to operate equipment at speeds other than these, some type of speed reducer is necessary. A V-pulley with two or more step-down diameters is very useful. However,



BRASS SHELL SOCKET ASSEMBLED

Fig. 26.

some very slow speed machines require driving speeds lower than can be obtained with a step-down pulley. In these cases a speed reducing jackshaft is necessary. The small pulley on the motor is belted to a larger pulley on the speed reducing jackshaft. A belt from a small pulley on the jackshaft is then connected to a larger pulley on the driven machine.

The difference between the speed of the motor and the speed of the driven machine varies directly as the diameter of the pulleys. By the use of the following rule, this principle can be used to determine the correct pulley size for any machine.

r.p.m. of motor x diameter of motor pulley = r.p.m. of machine x diameter of driven machine pulley

r.p.m. x D = r.p.m. x d

If any three figures are known, the fourth can be determined.

Example:

If a motor having a speed of 1,720 r.p.m. and a pulley diameter of 2 inches is to drive a machine at the speed of 860 r.p.m., what must be the diameter of the pulley on the driven machine?

r.p.m. of motor (1,720) x diameter of motor pulley (2 inches) = r.p.m. of driven machine (860) x diameter of driven machine pulley.

$$1{,}720 \times 2 = 860 \times d$$

$$d = \frac{1{,}720 \times 2}{860} = 4 \text{ inches}$$

d = Four inch diameter of pulley on driven machine

Suppose it is desired to determine the speed of a concrete mixer when the pulley arrangement shown above

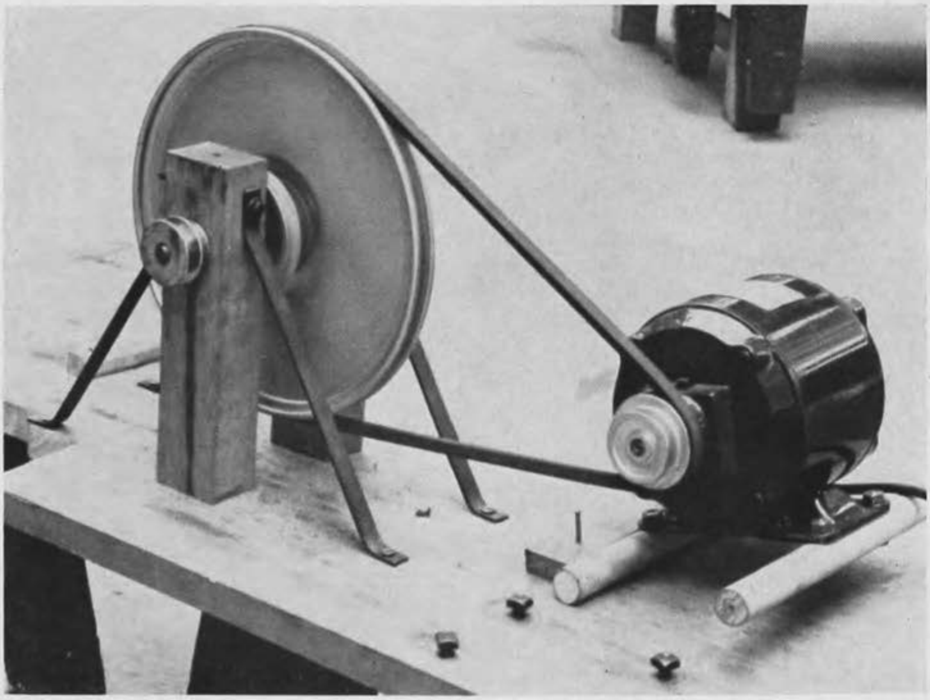


Fig. 27. By using a speed reducer, an electric motor which turns at high speed can be used to operate slower moving equipment.

is used with a motor having a speed of 1,740 r.p.m.

First, the speed of the jackshaft must be determined.

r.p.m. of motor (1,740) x D (2) = r.p.m. of jackshaft x d

$$d = \frac{1{,}740 \times 2}{10}$$

$$= 348 \text{ r.p.m.}$$

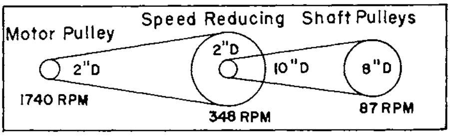


Fig. 28.

Since the small pulley is on the same jackshaft as the large one its speed is also 348 r.p.m.

To determine the speed of the concrete mixer, then:

r.p.m. of jackshaft (348) x Diameter of small pulley (2) = r.p.m. of mixer x d

$$348 \times 2 = \text{r.p.m.} \times 8$$

$$\text{r.p.m.} = \frac{348 \times 2}{8}$$

= 87 r.p.m. speed of concrete mixer

A ¼ or ⅓ horsepower motor can be used for many jobs about the farm if it is made to be portable. A simple mounting must be provided at each place the motor is to be used. For making a portable motor the following materials are required: ¼ or ⅓ horsepower motor, 10 feet of number 16 rubber covered extension cord, one 5 inch diameter 4-step pulley, four stove

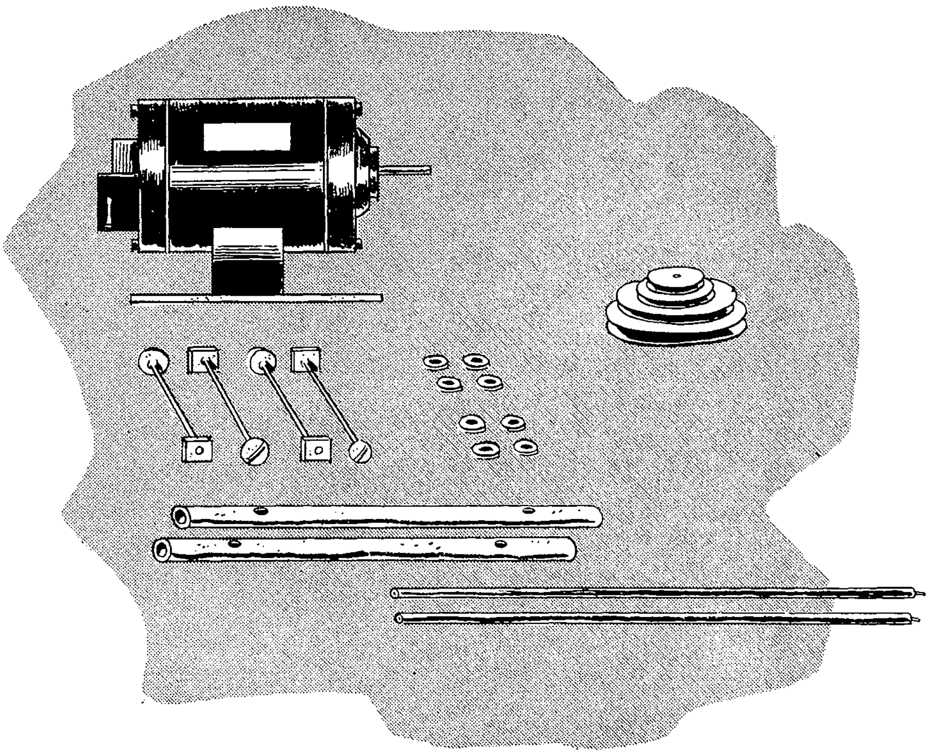


Fig. 29. An electric motor and the materials needed for making it portable.

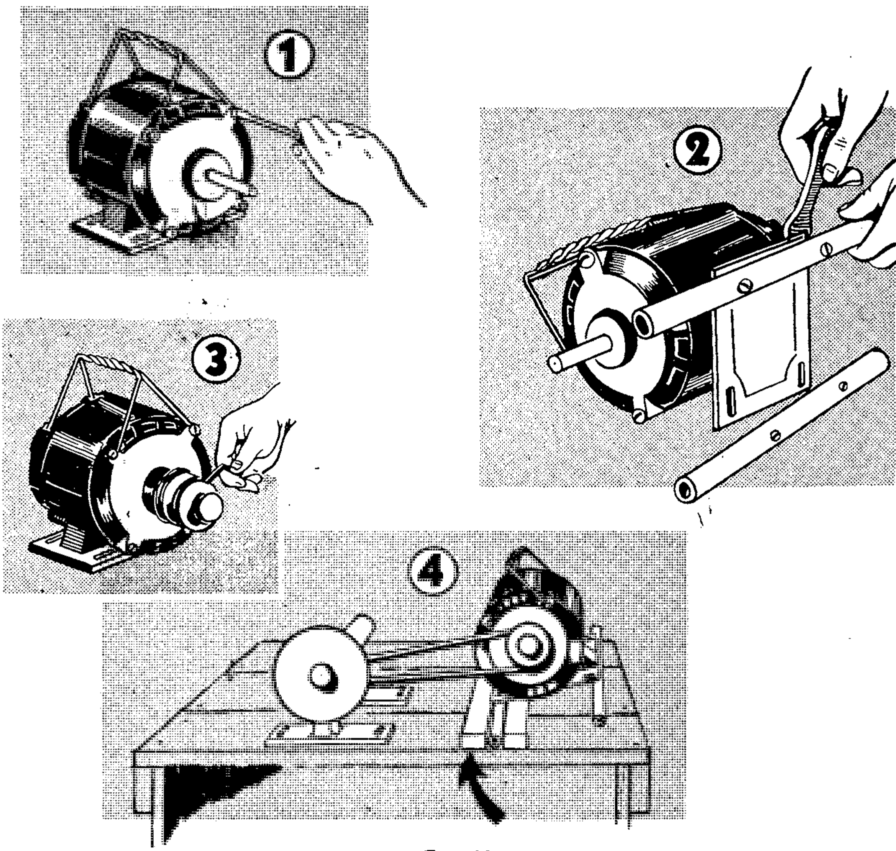


Fig. 30.

bolts and washers, two 12 inch long pieces of ¾ inch pipe drilled for mounting to the motor base, and two pieces of number 10 rubber covered wire about 18 inches long.

Procedure:

1. Twist the two pieces of rubber covered wire together. Make a hook on each end of each wire and fasten under the bolts on the top of the motor frame.
2. Bolt the pipe to the motor base.
3. Attach 4-step pulley to motor shaft. This type pulley makes it possible to turn equipment at various speeds without changing pulleys.
4. Mount the motor by placing one of the pipes attached to the base between two 2 inch x 2 inch wood strips fastened at a distance far enough away from the equipment to be driven so that the weight of the motor will keep the belt tight. The motor must always be mounted so that the top of the belt will travel toward it.

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